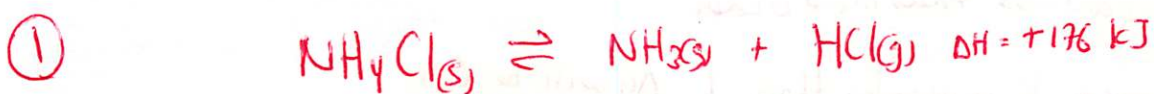
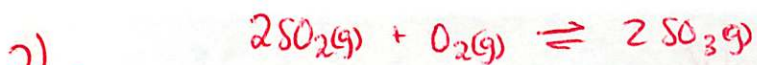


Equilibrium HMLK

①



- a No change b/c solids do not affect equilibrium. The equilibrium expression ~~does~~ is not affected by solids
- b Shift ~~left~~ Right. The increase in T favors the endothermic, forward Rxn.
- c ~~Shift~~ No change. There will be more moles of gas produced but they will occupy a larger volume which will keep the P_{NH_3} constant.
- d Shift Left. The P_{NH_3} will decrease ~~due~~ b/c it's being used to form more NH_4Cl to remove the excess HCl
- e No change the total P of system will increase but the P_{NH_3} will remain constant b/c the He does react in the Rxn so it will not affect the P_{NH_3} .
- f The catalyst will not affect the P_{NH_3} . It will just increase the rate at which the system reaches Equilibrium, but will not affect P_{eq}
- g mass NH_4Cl will increase b/c the gases will react to reestablish Eq. Partial P so more NH_4Cl forms
- h No change, the Reaction will reach Eq faster b/c more surface area but no change in P 's
- i Mass will \uparrow b/c the exothermic, reverse process will be favored making more NH_4Cl
- j $\Delta S > 0$ b/c there are gaseous molecules forming which have higher random motions than solids thus higher Entropy
- k $\Delta G = \Delta H - T\Delta S$ since ΔH is + and ΔS is + the higher T value will give an overall \rightarrow ΔG making it spontaneous
- l Since the Rxn is spontaneous @ high T, there will be more products thus a higher K value
- m $K_p = K_c (RT)^2$



2) a ΔS is (-) b/c 3 molecules are making 2 thus the Entropy is decreasing b/c there are ~~more~~ less particles thus more order.

b $\Delta G = -RT \ln K$ since K is greater than 1 ΔG will be (-)

c $\Delta G = \Delta H - T\Delta S$ Since ΔS is (-) and ΔG is (-), ΔH must be (-) to counteract the (+) $-T\Delta S$ value to make ΔG (-)

$$d \ K_p = K_c(RT)^{\Delta n} = (2.8 \times 10^{-2}) \left(\frac{0.0821}{1} \right) (727 + 273)^{-1} = 3.4$$

$$e \ \Delta G = -RT \ln K = -(8.31)(1000\text{K}) \ln(3.4) \times \frac{10^3 \text{ kJ}}{1000\text{J}} = \boxed{-10.2 \text{ kJ/mol}}$$

$$f \ Q = \frac{[\text{SO}_3]^2}{[\text{SO}_2]^2 [\text{O}_2]} = \frac{(0.72\text{mol})^2}{(2.50\text{L})^2 \left(\frac{0.40\text{mol}}{2.50\text{L}} \right) \left(\frac{0.6\text{mol}}{2.50\text{L}} \right)} = 45 \quad \text{since } K_c > Q$$

$280 > 45$ The Reaction needs

to shift right to produce more products to get $Q = K$

$$g \ 8.000\text{g SO}_3 \times \frac{1\text{mol SO}_3}{80\text{g SO}_3} = \frac{0.100\text{mol SO}_3}{2.50\text{L}} = 0.0400\text{M} = [\text{SO}_3]_i \quad P_i = \frac{0.100\text{mol} \cdot 0.0821}{2.50\text{L}}$$

$$0.32\text{g O}_2 \times \frac{1\text{mol O}_2}{32\text{g O}_2} = \frac{0.0100\text{mol O}_2}{2.50\text{L}} = 0.00400\text{M} [\text{O}_2]_i$$

$$\begin{array}{l} 2\text{SO}_3 \rightleftharpoons 2\text{SO}_2 + \text{O}_2 \\ \text{I } 0.0400\text{M} \qquad \qquad \qquad 0 \qquad \qquad 0 \\ \text{C } -0.0080\text{M} \qquad \qquad \qquad +0.0080\text{M} \quad +0.0040\text{M} \\ \text{E } 0.032\text{M} \qquad \qquad \qquad 0.0080\text{M} \quad 0.0040\text{M} \end{array}$$

$$K_c = \frac{(0.0080\text{M})(0.0040\text{M})}{(0.032\text{M})^2} = \boxed{0.00025}$$

or 4000 For Rxn given

h ~~higher~~ Since ΔH is - and the Rxn's K_c is now 4000 the temp must be lower to allow the E_c to shift to the right favouring the endothermic process



(2)

a $\text{Rate}_f = k_f [\text{NO}]^2 [\text{O}_2]$ $\text{Rate}_r = k_{rev} [\text{NO}_2]^2$

@ Eq $\text{Rate}_f = \text{Rate}_r$ $k_f [\text{NO}]^2 [\text{O}_2] = k_{rev} [\text{NO}_2]^2$

$K_c = \frac{[\text{NO}_2]^2}{[\text{NO}]^2 [\text{O}_2]}$

$\frac{k_f}{k_{rev}} = \frac{[\text{NO}]^2}{[\text{O}_2][\text{NO}_2]^2}$

Thus $K_c = \frac{k_f}{k_{rev}} = \frac{2.6 \times 10^3 \frac{\text{L}^2}{\text{mol}^2 \text{s}}}{4.1 \frac{\text{L}}{\text{mol s}}} = \boxed{634}$

b $\text{Rate}_f = k_f [\text{NO}]^2 [\text{O}_2] = (2.6 \times 10^3 \frac{1}{\text{M}^2 \text{s}}) (0.0060 \frac{\text{M}}{\text{s}})^2 (0.29 \frac{\text{M}}{\text{s}}) = 0.027 \frac{\text{M}}{\text{s}}$



I	0.0400M	0	0
C	-0.0060	+0.0060	+0.0030
E	0.034	0.006	0.0030

$\frac{0.20 \text{ mol NO}_2}{5.0 \text{ L}} = 0.0400 \text{ M} = [\text{NO}_2]_i$

Change NO₂ is 15% $0.0400 \text{ M} \times 0.15 = 0.006 \text{ M}$

$K' = \frac{(0.006)^2 (0.0030)}{(0.034)^2} = 9.34 \times 10^{-5}$

$K = \frac{1}{9.34 \times 10^{-5}} = 1.07 \times 10^4 \approx 634$



b $8.95 \text{ g AgCl} \times \frac{1 \text{ mol AgCl}}{143.5 \text{ g AgCl}} = 0.0624 \text{ mol AgCl} \times \frac{1 \text{ mol Ag}^+}{1 \text{ mol AgCl}} = \frac{0.0624 \text{ mol Ag}^+}{(100 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}})} = 6.24 \times 10^{-4} \text{ M Ag}^+ = [\text{Cl}^-]$

$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = (6.24 \times 10^{-4} \text{ M})(6.24 \times 10^{-4} \text{ M}) = \boxed{3.89 \times 10^{-11}}$

c $95.3 \text{ g MgCl}_2 \times \frac{1 \text{ mol MgCl}_2}{95.3 \text{ g MgCl}_2} \times \frac{2 \text{ mol Cl}^-}{1 \text{ mol MgCl}_2} = \frac{2 \text{ mol Cl}^-}{(250 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}})} = 8.00 \text{ M Cl}^-$

$K_{sp} = [\text{Ag}^+][\text{Cl}^-] = 3.89 \times 10^{-11}$

$[\text{Ag}^+] (8.00 \text{ M}) = 3.89 \times 10^{-11}$

$[\text{Ag}^+] = 4.86 \times 10^{-12} \text{ M} \times \frac{1 \text{ mol AgCl}}{1 \text{ mol Ag}^+} = \boxed{4.86 \times 10^{-12} \text{ M}}$

5 a $\text{PbCl}_2 \rightleftharpoons \text{Pb}^{2+} + 2\text{Cl}^-$

X X 2X

$$K_{sp} = [\text{Pb}^{2+}][\text{Cl}^-]^2 = 1.6 \times 10^{-5}$$

$$x(2x)^2 = 1.6 \times 10^{-5}$$

$$4x^3 = 1.6 \times 10^{-5}$$

$$x = \boxed{0.0159 \text{ M} = [\text{PbCl}_2]}$$

b $[\text{Cl}^-] = \frac{0.250 \text{ mol Cl}^-}{(500 \text{ mL}) \left(\frac{1 \text{ L}}{1000 \text{ mL}} \right)} = 0.50 \text{ M Cl}^-$

$$[\text{Pb}^{2+}] = \frac{K_{sp}}{[\text{Cl}^-]^2} = \frac{1.6 \times 10^{-5}}{(0.5 \text{ M})^2} = \boxed{6.4 \times 10^{-5} \text{ M}}$$

c $60.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times 0.0400 \text{ M BaCl}_2 \times \frac{2 \text{ mol Cl}^-}{1 \text{ mol BaCl}_2} = \frac{4.8 \times 10^{-3} \text{ mol Cl}^-}{(0.0600 \text{ L} + 0.0600 \text{ L})} = 4.0 \times 10^{-2} \text{ M Cl}^-$

$$60.0 \text{ mL} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times 0.0300 \text{ M Pb(NO}_3)_2 \times \frac{1 \text{ mol Pb}^{2+}}{1 \text{ mol Pb(NO}_3)_2} = \frac{1.8 \times 10^{-3} \text{ mol Pb}^{2+}}{(0.0600 \text{ L} + 0.0600 \text{ L})} = 1.5 \times 10^{-2} \text{ M Pb}^{2+}$$

$$Q = [\text{Pb}^{2+}][\text{Cl}^-]^2 = (1.5 \times 10^{-2} \text{ M})(4.0 \times 10^{-2} \text{ M})^2 = 2.4 \times 10^{-5}$$

$$Q > K_{sp}$$

$2.4 \times 10^{-5} > 1.6 \times 10^{-5}$ so a ppt will form b/c $Q > K$

$x \quad x \quad \text{b/c } [\text{Ag}^+] = [\text{Cl}^-]$

$$[\text{Ag}^+][\text{Cl}^-] = 1.8 \times 10^{-10}$$

$$x^2 = 1.8 \times 10^{-10}$$

$$[\text{Cl}^-] = x = 1.34 \times 10^{-5} \text{ M}$$

$$[\text{Pb}^{2+}][\text{Cl}^-]^2 = 1.6 \times 10^{-5}$$

$$(x)(2x)^2 = 1.6 \times 10^{-5}$$

$$4x^3 = 1.6 \times 10^{-5}$$

$$x = 1.5 \times 10^{-2} \text{ M} \times 2 = 3.2 \times 10^{-2} \text{ M} = [\text{Cl}^-]$$

$$1.3 \times 10^{-5} \text{ M} < 3.2 \times 10^{-2} \text{ M}$$

↑
AgCl will ppt first b/c it needs a [lower] of Cl^- to reach saturation and ppt

or (Better)

$$(0.150 \text{ M Pb}^{2+})(\text{Cl}^-)^2 = 1.6 \times 10^{-5} \quad [\text{Cl}^-] = 1.0 \times 10^{-2} \text{ M}$$

$$(0.120 \text{ M Ag}^+)(\text{Cl}^-) = 1.8 \times 10^{-10} \quad [\text{Cl}^-] = 1.5 \times 10^{-9} \text{ M}$$

Thus less than
so AgCl ppt's 1st

when the 2nd cation ppt's, the first should have totally ppt and only the amount left in solution will be the one

(3)

e when the 2nd cation ppt's the $[Cl^-]$ needs to be $1.0 \times 10^{-2} M$ (see d)

$$\text{So } [Ag] = \frac{K_{sp}}{[Cl^-]} = \frac{1.8 \times 10^{-10}}{1.0 \times 10^{-2} M} = 1.8 \times 10^{-8} M$$

$$\% = \frac{1.8 \times 10^{-8} M}{0.120 M} \times 100\% = \boxed{1.5 \times 10^{-5} \%}$$

↑
original %

f $\Delta H - T\Delta S = -RT \ln K$

$\Delta H = \underset{\substack{\uparrow \\ (+)}}{T\Delta S} - \underset{\substack{\uparrow \\ (-) \text{ b/c } 1 > K}}{RT \ln K}$ so $RT \ln K$ added to $+T\Delta S$ so ΔH is (+) meaning the Rxn is endothermic.